ROENTGENOLOGY OF THE PHARYNX AND UPPER ESOPHAGUS

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Routine examinations of the oropharynx, pharynx, and pyriform sinuses for all conditions which may involve them are too often neglected by roentgenologists because of their unfounded belief that little is to be learned by roentgen studies aside from the detection of foreign bodies. With this one exception, they are too apt to believe that examination of the food passages begins with the esophagus. As a matter of fact, the region above this part of the tract is a very prolific field for roentgenological study.

The basis for diagnostic ability in this region must be a knowledge of the anatomy of these spaces and their boundaries, of the normal roentgenological appearances at all ages, of the normal range of movability of the movable structures, and the physiology of each portion of the tract from the mouth down, especially as it may be concerned in the act of swallowing. Not until these essential points are mastered can one undertake to interpret the roentgenologic appearances and phenomena resulting from pathological processes and anomalous conditions.

In the study of the upper food passages must be included the oropharynx, the pharynx, the pyriform sinuses, and the upper portion of the esophagus, and to these must be added the interrelated adjacent anatomical structures and boundaries, which include the tongue, soft palate and uvula, posterior pillars, epiglottis and vallecula, the arytenoid cartilages of the larynx in particular and the larynx as a whole, the aryepiglottic folds, the postpharyngeal wall and space, and the retrolaryngeal and retrotracheal spaces.

This much neglected field has been studied by several authors from various angles, although not to the extent which it deserves. We would call attention to Scheier's early studies of swallowing, appearing in 1910 (1), and to those of Mosher in 1927 (2) and Barclay in 1930 (3). Our own observations on this mechanism were presented in the latter year (4). Iglauer and Ransohoff (5) and Tucker (6) have supplied valuable data in regard to the appearances of retropharyngeal and retrotracheal abscess. Manges (7, 8) has contributed largely to our knowledge of the roentgen-
ology of foreign bodies. Brown and Reineke (9) presented a preface to the study of the soft tissues of the neck in 1928. The first extensive studies of the upper air and food passages and the soft tissues of the neck, however, seem to have been made by Hay (10), in 1929, in his collective investigations of the normal and pathological roentgenographic material which had long been buried in our clinic. As additional material has collected since his report, we have been able from time to time to add a few new phases in connection with the air and food passages (11, 12).

The various conditions for which the pharynx and upper esophagus may be examined include foreign bodies, neoplasms, inflammatory conditions, paralyses, injuries, and anomalies. The subject of foreign bodies will not be included in this presentation, except in connection with differential diagnosis.

The basis for the diagnostic possibilities in this location are the following factors:

1. The soft tissues of the neck surround a more or less open, air-containing space above the esophagus, comprising the oropharynx, pharynx, pyriform sinuses, and larynx.

2. The structures which bound this space cast definite shadows and can therefore be differentiated by contrast.

3. The air space can be encroached upon or displaced visibly by inflammatory swellings or neoplasms.

4. The structures bounding the space can be appreciably and characteristically altered in appearance or displaced by the same processes.

5. A certain normal range of movability of many of the structures can be determined, and fixation or restriction in movement can then be detected by fluoroscopic observations. These structures include the soft palate and uvula, the tongue, the larynx as a whole, and the arytenoid cartilages separately.

6. The collapsed potential space of the upper esophagus can be filled with an opaque medium to outline its lumen and its location.

7. The dense cervical spine, with its fixed relations, serves as a means of estimation of displacements and the comparative measurements of spaces, their locations, and the thickness of their walls.

**Technic**

Frequent references have been made elsewhere to the technic of examination of these regions in infants and young children. What follows applies only to adults and older children.

**A. Fluoroscopy:** In the examination of the pharynx and upper esophagus fluoroscopic study is far more important in many re-
spects than roentgenographic records. Fluoroscopy is the only means of showing movements and changes in lumen during respiration, speech, and swallowing. It should precede the roentgenographic exposures in order to indicate any special modifications in the latter technic. The eyes must be accommodated beforehand, until one is able to see the ventricular space of the larynx, provided it is visible at all. It always comes in for its share of study. During the observations, the patient is asked to pronounce the various vowel sounds, particularly "a" and "e", which opens up the space just before, during, or directly after the pronunciation. Incidentally, if the ventricular space is seen to be normal, one may practically exclude an inflammatory condition or growth involving the larynx—especially of the intrinsic type, and usually of the extrinsic type also—as well as recurrent laryngeal nerve paralysis. If the ventricular space is abnormal in appearance, one of these three conditions is almost certainly present.

Next, the movements of the arytenoid cartilages should be observed during speech and in relation to swallowing. The movements of these structures may be interfered with by near-by growths as well as by growths involving the larynx directly, as, for example, postcricoid cancer of the upper esophagus. These cartilages have both lateral and sagittal movements, and they may vary in appearance and relations with the position of the neck and breathing; hence the value of fluoroscopy in various directions.

The next step in the detection of lesions in the oropharynx, pharynx, pyriform sinus region, and upper esophagus, is observation of the swallowing act in order to determine the following points:

1. The movability of the soft palate, tongue, epiglottis, arytenoids and the entire larynx.
2. The outlines of possible growths involving the soft palate, epiglottis, base of the tongue, pharynx, pyriform sinuses, and upper esophagus. Growth of the dorsum or root of the tongue interfere with the forward projection of that organ. Those of the soft palate prevent elevation of that structure on the attempt to whistle. Lesions of the pharynx and pyriform sinuses interfere with the swallowing act in various ways.
3. The integrity of the motor mechanism of the oropharynx, pharynx, and upper esophagus.
4. The patulousness of the food passages.
5. The position of the food passages.

For purposes of observing the swallowing act, various types of opaque media are employed. The preference of our endoscopic consultants has led us to employ bismuth subcarbonate rather than barium sulphate. The patient is first asked to swallow a sus-
pension of the bismuth in a chocolate malted-milk mixture. If any suspicion of abnormality is observed, a semisolid mixture of bismuth and jam or marmalade is next employed. Whether or not apparent abnormalities are observed, the patient is next given a capsule filled with bismuth (a number "0" capsule thoroughly filled so that it will sink in water serves the purpose). This should be swallowed without water, except for a small amount to moisten the mouth.

**B. Roentgenography:** Roentgenograms are made after a thorough fluoroscopic study. Usually in this locality the lateral view is the essential one. One exposure is made without the use of the opaque medium, and during phonation if this is for any reason desirable. A second lateral exposure is made with an opaque medium, using any one or repeated exposures with all of the vehicles mentioned above, as found advantageous by fluoroscopic study or necessary to obtain the best details.

It may be asked why all of these roentgenological procedures are necessary when any lesion we may be able to show can be detected easily by either direct view, indirect mirror examination, or direct endoscopic vision. The answer is that many patients are referred to us solely because of symptoms, and it is necessary to determine whether or not such clinical examinations must be made. Moreover, it is to the advantage of the laryngologist or the bronchoscopist to know the full extent of the pathological process before he examines the case, in order that nothing may be overlooked. The information obtained by the roentgenologist is often of assistance in completing the diagnosis, as well as a source of assurance. An excellent example of the value of such thorough study is illustrated by the following case:

A male of fifty-four had had for the past four months a progressive glandular swelling of the left side of the neck. He did not complain of sore throat, but had dysphagia, a cough, altered voice, and pain in the left side of the neck. He had lost 40 pounds in weight. No direct examination had been made of the throat. We were requested to examine the chest for evidences of metastasis, and the esophagus. Examination of the neck showed a much thickened soft palate, shallow and irregular pyriform sinuses, widened retropharyngeal space, ulceration of the base of the tongue and vallecula, thickened arytenoids, and disturbance of the swallowing act permitting fluids to enter the larynx. The appearances were regarded as due to an extensive growth to which the cervical swelling was secondary. Examination of the chest showed evidences of aspiration pneumonia but no metastasis. Endoscopic examination revealed an infiltrating and ulcerative neoplastic process involving the soft palate and base of the tongue and extending into the pharynx and larynx. This was detected subsequent to our roentgenologic diagnosis. Biopsy showed the primary growth to be squamous carcinoma.

The ease of detection of retropharyngeal and retrotracheal abscesses is another good example of roentgenologic aid in reaching a correct diagnosis.
The Normal Swallowing Act

The roentgenologic observations of the physiological factors involved in the swallowing act deserve special mention. Briefly, the stages as observed fluoroscopically, and as we have been able to demonstrate them, in part, roentgenographically, are as follows:

1. Filling of the mouth and movement of the base of the tongue backward toward the postpharyngeal wall.

2. As the bolus begins to move backward from the mouth, the base of the tongue comes against the postpharyngeal wall and tilts the epiglottis very slightly backward. Coincidentally the larynx rises and the arytenoid cartilages come in contact with the under surface of the epiglottis, so that the tongue, epiglottis, and arytenoids form a single homogeneous shadow. The meeting of the arytenoids and epiglottis closes off the air passage into the larynx.

3. As seen by the fluoroscope, the bolus then enters the pharynx and immediately passes down the esophagus. This movement is so rapid, however, that the exact action of the structures concerned could not be determined, though we felt sure that there was a sudden squeeze of the pharynx to force the bolus into the esophagus while the air passage and the oropharynx were shut off.

4. Return of all structures to the rest position as the bolus disappears down the esophagus.

Since the publication of these observations (4) in 1930, we have studied with much interest the mechanism of swallowing as described by Barclay (3). He gives the following stages according to his observations:

1. The nasal cavity and mouth are shut off.

2. The larynx is raised and closed by coming in contact with the back of the tongue.

3. The pharyngeal space is obliterated by the raising of the larynx and retraction of the tongue.

4. The pharynx opens up, and with the nose, mouth, and air passage shut off, a negative pressure is obtained by the larynx dropping and the tongue going forward. (The existence of an instantaneous negative pressure was determined by inserting a rubber catheter through the nose down into the pharynx and observing the readings of a water manometer connected with the outside end of the catheter.)

5. During this procedure the pyriform sinuses still remain high and in close relation with the epiglottis.

6. Food is tipped back over the tongue and is sucked into the open mouth of the pyriform sinuses, which, as the bolus is received, drop from the epiglottis down to their normal position, thus opening the larynx after the food has passed down.
The food is then probably sucked some distance down the esophagus.

The differences between Barclay's observations and deductions and our own led us to further investigations of the swallowing act. We found that we differed from his views in only two essential respects, namely in our belief that the epiglottis and not the back of the tongue closes off the air passage, and that the pharynx has a squeezing mechanism by which the food is propelled into and down the upper esophagus and not a negative pressure effect by which it is drawn down. We have found, as Barclay states, that many individuals must be studied in order properly to recognize the various phases of the act, since modifications or slight variations are to be found in different persons.

The swallowing mechanism is a far more complicated coordinated process than is generally realized. In order to swallow properly, the nasal and laryngeal air passages must of necessity be closed off, the bolus must move from the mouth through the oropharynx into the pharynx, and the oral cavity must then be closed off to prevent regurgitation. The bolus must then be propelled from the pharynx and pyriform sinuses into the esophagus, where it is taken care of by a different mechanism. More happens during this momentary act than one realizes who has not observed it fluoroscopically, tried to catch the various phases by roentgenograms, and to determine the various factors in the complete act on his own person.

To understand any roentgenological study of the swallowing act, it is necessary first to become familiar with the shadows of the various structures concerned. Fig. 1 shows most of the important structures at the rest period, before swallowing begins. The back of the tongue is well forward, leaving an open air space posterior to it, the oropharynx above and the pharynx below. The air space terminates below posteriorly in the pyriform sinuses and in front in the laryngeal vestibule, with the shadow of the superimposed arytenoid cartilages between. The epiglottis projects directly upward, just a little posterior to the tongue. The open space between the two structures is the vallecula. The fainter shadow of the soft palate and uvula can be seen above and behind that of the tongue.

Everyone knows that during the act of swallowing the larynx rises considerably. With a little practice the author was able to hold his larynx in this position in order to have a roentgenographic exposure made (Fig. 2). In this gross phase of the act the oropharynx, pharynx, and pyriform sinuses have collapsed. As the larynx has become elevated, the arytenoid cartilages have come in contact with the under surface of the epiglottis, and this approxi-
FORMATION has closed off the larynx completely. We cannot determine the exact position of the epiglottis at this stage because its shadow and those of the arytenoids, the tongue, and the postpharyngeal wall are fused as one homogeneous density. We do know that the lower end of the epiglottis is attached to the inner mesial aspect of

![Fig. 1](image1.png) ![Fig. 2](image2.png)

**Fig. 1.** Lateral Roentgenogram of the Neck, Showing Most of the Structures Concerned in the Swallowing Mechanism in Their Relations BEFORE THE ACT BEGINS

1. Posterior border of the tongue. 2. Soft palate and uvula. 3. Epiglottis, with vallecula in front. 4. Arytenoid cartilages of the larynx, well separated from the epiglottis. 5. Vestibule of the larynx. Note that the posterior border of the tongue is well forward from the postpharyngeal wall, leaving a large air space—the oropharynx above and the pharynx below, the latter terminating posteriorly and below in the pyriform sinuses and in front and below in the vestibule of the larynx. The superior cornua of the thyroid cartilage are seen passing upward to articulate with the posterior cornua of the hyoid bone.

**Fig. 2.** Lateral Roentgenogram Made During the Gross Phase of the Swallowing Act, but with Nothing to Swallow

The larynx was voluntarily held up in the swallowing position while the exposure was made. Note that the oropharynx, pharynx and pyriform sinuses are obliterated as air spaces or collapsed. The tongue is back against the postpharyngeal wall, and these two structures, together with the epiglottis and arytenoid cartilages, have become one homogeneous shadow. The soft palate and uvula have ascended into the whistling position and have closed off the nasopharynx. The approximation of arytenoids and epiglottis has closed off the air passage into the larynx.

the anterior portion of the thyroid cartilage, and that its only possible motion is a transmitted one posteriorly. We know also that in the frequent cases of congenital narrowing or curling of the epiglottis in infancy, which are so often responsible for the symptoms attributed to an enlarged thymus, it is subject to sufficient posterior movement to close the glottis during respiration.
Fluoroscopic observations during swallowing show us that the epiglottis does not move backward and downward as a lid, but that it is brought upward, as the larynx rises, against the posterior aspect of the tongue and may be pushed very slightly backward thereby. Its position can be determined just as liquid food goes past it because of its negative shadow when surrounded by an opaque bolus (Figs. 6 and 7). We feel sure that the epiglottis comes between the arytenoids and the tongue when the larynx rises, and that in this way the air passage is closed off. No doubt other structures aid in closing off this passage, since an individual can swallow without an epiglottis.

Fluoroscopically the soft palate is seen to be elevated as in the whistling position as the food passes over the back of the tongue, and to close off or help close off the nasopharynx.

The following is a résumé of the sequence of events in swallow-
ing as we have been able to determine them by fluoroscopic and roentgenographic observations and personal experiences:

1. The food is held in the mouth between the anterior portion of the tongue and the hard palate and is prevented from trickling down too soon by elevation of the posterior part of the tongue. The bolus is held momentarily in this position.

2. A rhythmic movement of the tongue, comparable to intestinal peristalsis, carries the bolus backward to the oropharynx. The force of this movement can be comprehended by holding a finger well back in the mouth at this period.

3. Simultaneously three things happen: (a) the larynx is elevated and the arytenoids come in contact with the under surface of the epiglottis, which does not give way because of the backward pressure of the tongue against it; (b) the soft palate and uvula are elevated to the whistling position to close off the nasopharynx; (c) the pharynx and pyriform sinuses are collapsed as a potential space comparable to the upper esophagus.

4. Immediately the rolling, peristaltic-like action of the tongue forces the bolus into the easily dilatable potential space of the closed pharynx and pyriform sinuses and the tongue automatically closes off the oropharynx by coming in contact with the postpharyngeal wall (Figs. 4, 6, 7). While liquid food passes down across the entire dorsum of the tongue, most of it goes through a momentarily made gutter in the midline.

5. The exact function of the posterior pillars at this point is uncertain, since we cannot see them. It is our hope to be able to overcome this difficulty by placing opaque metal clips on the
posterior pillars in order to determine their possible function, their approximation, and its time.

(6) The receptive pharynx now squeezes the bolus into the upper esophagus, which takes care of it by peristaltic action, aided more or less by gravity. The cricopharyngeus must act as a sphincter. The mouth, nose, and air passages remain closed off until the bolus is in the esophagus. The fact that the pharynx can

![Fig. 6](image1)
![Fig. 7](image2)

**FIG. 6. RETARDED SWALLOWING FUNCTION IN AN AGED PATIENT WITH AN OBTURATOR CLOSING A CLEFT PALATE DEFECT**

The motor function was partly slowed because of age, which quite often occurs, accounting for the frequent choking of elderly people during swallowing. Note that the pharynx is about filled, even above the vallecula, and the pyriform sinuses nearly so. The epiglottis and approximated arytenoids are protecting the air passage. Note the upright position of the epiglottis, with little or no backward tilting. This patient did not choke at any time, even though the phenomena were repeated frequently.

**FIG. 7. COMPLETE FILLING OF THE PHARYNX AND PYRIFORM SINUSES IN THE CASE SHOWN IN FIG. 6**

A second or two later the pharynx contracted and forced the entire contents suddenly down the esophagus. This would seem to oppose the negative pressure theory of pharyngeal and upper esophageal filling.

fill up by the *pushing* of food into it and can then *squeeze* its contents down into the esophagus was further demonstrated in a subject in whom the swallowing function was much retarded by the presence of an obturator to close a cleft palate defect and by the decreased muscular tone of old age (Figs. 6 and 7). The pyriform sinuses and pharynx in this patient were seen to fill up slowly but completely to a level well above the epiglottis, with complete protection to the air passage. After a second or two the filled pharynx *squeezed* its contents into the upper esophagus and the structures then returned to the rest positions.
All structures return to the rest positions (Fig. 5).

These observations seem to show that the epiglottis is largely responsible for the closing of the air passages, acting as a sort of lid to which the arytenoids become approximated when the larynx becomes elevated. It is our belief that no negative pressure mechanism is involved in the act, but that a positive pressure from pushing or squeezing is the real propelling force or factor con-

![Figure 8](image)

**Fig. 8. Carcinoma at the Base of the Tongue and the Vallecula of the Epiglottis, with the Crater Well Outlined by Opaque Medium After the Bolus Has Been Swallowed and Has Passed Down into the Esophagus**

Note the clear area of the epiglottis in the midst of the opaque medium shadow, and the arytenoids and larynx dropped downward into the rest or post-swallowing position.

cerned in the descent of the food. It is true that negative pressure must be present and measurable at some time or at some phase of the swallowing act, since it is apparent to anyone who watches the swallowing of liquid opaque media that more or less air is sucked down the food passage. We do not believe, however, that this is an essential factor in the swallowing mechanism, but rather that the air is drawn down on the principle of the Sprengel air pump as the column of liquid descends. Further proof of the contracting function of the pharynx is exhibited in the action of an opaque capsule in the pharynx in any case in which there is some slight obstacle to its engagement in the upper esophagus. It can be seen turning around in various directions or even being regurgitated back and forth.

**Diagnosis of Pathological Conditions**

*Tumors*: Tumors in the pharynx involve the walls of a more or less open air space, and therefore present somewhat different
roentgenological aspects than those arising in the upper esophagus, which is a closed or potential space. Growths in the upper locality are manifest in a general way by changes in outline due to swelling or infiltration of the soft structures—clean cut if benign, more or less hazy if malignant—by encroachment upon the lumen of the space, and by crater-like formations. These various appearances may be intensified by coating with an opaque medium (Fig. 8). All of these appearances have been described by Hay (10). The normal movements of speech, swallowing, and other procedures are interfered with more or less.

Growths involving the soft palate cause swelling and thickening of its shadow. The palate becomes more or less fixed. The best test for immobility is to ask the patient to whistle. Normally, during this procedure, the soft palate becomes elevated, with a decided upward angulation, but in the presence of a growth this motion is limited or entirely prevented. Swallowing may be difficult, especially with the use of the capsule.

Malignant growths on the back or at the base of the tongue interfere considerably with its movement, so that the patient is unable to protrude the organ forward properly. Swallowing is more or less interfered with, especially if the capsule is employed. Abnormal irregularities in outline are observed. These consist of localized swellings if benign growths are present, as in case of a lingual thyroid. With malignant growths the outlines are more irregular, and there may or may not be a crater formation. Benign growths are less likely than malignant ones to interfere with protrusion of the tongue or swallowing.

The shadow of the epiglottis may be enlarged or irregular in outline or partly missing. The vallecula is often too large if this region is affected, or it may present an irregular outline. The swallowing mechanism is more or less disturbed, especially when the capsule is used.

The most frequent appearance arising from pharyngeal wall involvement is a thickening and blurring of the shadow of the postpharyngeal tissues. This may be unilateral, producing a double shadow. Postpharyngeal growths present the most noticeable abnormal appearances. Swallowing is considerably retarded and interfered with, and handling of the capsule may be impossible or very difficult.

The pyriform sinuses show indefinite outlines and appear shallow. The swallowing function is greatly disturbed. Involvement of neighboring laryngeal structures is manifested by blurring of their outlines, swelling, or interference with movement of the arytenoids or the larynx as a whole.

Aside from the epiglottis, the arytenoids are the only portion
of the larynx to be discussed in this connection, and that only because they are intimately concerned in the swallowing act and are so often the seat of infiltration from growths in nearby structures. They may appear larger or blurred in outline, or their movements may be limited or obliterated.

FIG. 9. CARCINOMA OF THE UPPER ESOPHAGUS

Note the distinct widening of the retrotracheal space. There was an obstacle to the swallowing of liquids above the suprasternal notch level, with irregularity of the lumen above. The capsule was completely blocked. The larynx is normal in appearance, especially in respect to the clean-cut ventricular space. Endoscopy showed carcinoma of the upper esophagus.

FIG. 10. CARCINOMA OF THE UPPER ESOPHAGUS

By fluoroscopy it was found that the opaque liquid suspension descended readily to a point corresponding to the pyriform sinuses and was then regurgitated up and down between this point and the oropharynx. With each regurgitation a small amount of the suspension trickled through the cervical esophagus (1), which showed a narrowed and irregular lumen. Note (2) that there is marked swelling of the retrolaryngeal and retrotracheal space, (3) that the trachea is greatly encroached upon. (4) that the column of opaque suspension is in the center of the swollen retrotracheal space. The swelling and tracheal encroachment had to be carefully watched in order to have warning of the necessity for tracheotomy, which was soon required. This particular exposure was made at a period when the difficult attempt at swallowing caused a prolonged elevation of the larynx so that its shadow cannot be differentiated from that of the adjacent structures. Endoscopy showed a fungating lesion involving the posterior surface of the cricoid and extending downward below the level of the ericopharyngeus.

Growth in the upper portion of the esophagus may be manifest by changes in the lumen, swelling of the retrolaryngeal or retrotracheal space, and involvement of the neighboring structures. Changes in the lumen of the esophagus may be manifest as obstructions to the passage of liquid suspensions or a backing up in
the pyriform sinuses or pharynx; obstruction to the capsule, which engages with considerable difficulty or not at all; narrowing or irregularity of the lumen when filled with a liquid suspension (Fig. 10). Swelling of the retrolaryngeal or retrotracheal space is easily detected (Figs. 9 and 10). The tracheal lumen may be encroached upon (Fig. 10). The esophageal canal is always found in the center of the space in the presence of cancer and foreign bodies (Fig. 17), whereas in swelling due to retroesophageal abscess it is anterior to the swelling (Figs. 18 to 20). When the neighboring structures are involved, one may find irregularities or obliteration of the pyriform sinuses, swelling or blurring of the arytenoids, absence of the laryngeal ventricles (Figs. 9 and 10), blurring of the vocal cords and ventricular bands (Figs. 9 and 10), and blurring of the outlines of the laryngeal vestibule.

Inflammatory Conditions: The inflammatory condition most commonly encountered in connection with the pharynx and upper esophagus is retropharyngeal, retroesophageal or retrotracheal abscess. The diagnosis depends upon the history of the case and the interpretation of any increase in the measurement of the retropharyngeal or retrotracheal space in front of the cervical spine. One must always have in mind the width of this space as deter-
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Mined by Hay (10). His figures for the retropharyngeal space at different ages are as follows, \( C \) being the width of the shadow of the ossified portion of the body of the fifth cervical vertebra in the lateral view.

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Width of Shadow (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First year, never over</td>
<td>1.5 C</td>
</tr>
<tr>
<td>First to third year, never over</td>
<td>0.5 C</td>
</tr>
<tr>
<td>Third to sixth year, never over</td>
<td>0.4 C</td>
</tr>
<tr>
<td>Sixth to fourteenth year, never over</td>
<td>0.3 C</td>
</tr>
<tr>
<td>Average adult males</td>
<td>0.2 C</td>
</tr>
<tr>
<td>Average adult females</td>
<td>0.1 C</td>
</tr>
</tbody>
</table>

These measurements must always be borne in mind in attempting to diagnose pathological conditions involving the soft structures of the neck. There is always a variable increase in the space behind the larynx and a still greater increase behind the trachea.

Abscess may be encountered at any age, but as a result of quite different causes and in quite different locations. The diagnosis is exceedingly easy if one is familiar with the roentgenological anatomy of the neck, yet the literature reveals little use of this means of diagnosis. It may be safely stated that abscess of the posterior upper food passage can in most instances be diagnosed roentgenologically before the usual clinical conclusions have been reached or the exact condition even suspected, especially in cases referred from general medical practice.

**Fig. 13**

*Retropharyngeal Abscess in a Child of Twenty Months, Apparently Secondary to Cervical Lymph Node Infection*

Note the greatly widened retropharyngeal space

**Fig. 14**

*Case Illustrated in Fig. 13 After Evacuation of the Abscess*

The retropharyngeal space is now normal for the age of the individual.
The appearances differ materially according to the etiology of the inflammatory process and its location at different age periods. In infancy and early childhood abscess is usually due to lymphatic spread of infection to the retropharyngeal space from nasal, middle ear or mastoid, tonsillar or pharyngeal disease. The postpharyngeal space is usually affected, above the level of the larynx (Figs. 13 to 16). At this age period the retropharyngeal space differs considerably with the two respiratory phases and the natural degree of relaxation of the soft tissues. During the inspiratory phase the pharynx is often filled with air and the postpharyngeal space is comparatively narrow; during expiration the space may be much wider, when the pharyngeal space is completely or partially collapsed (Figs. 11 and 12). Estimates of the width of the retropharyngeal space during infancy must, therefore, be determined on the basis of the appearances during both phases of respiration.

During late childhood and adult life, abscess posterior to the food passage is more often due to penetrating foreign bodies which lodge in the pyriform sinuses and upper esophagus. Hence, the swelling is more often found at these ages at the level of the larynx or below (Figs. 17 to 20). The diagnostic feature is a swelling of the soft tissue space behind the pharynx, larynx, or trachea, the
esophageal location being determined at the latter level by the swallowing of an opaque medium. It is usually well forward near the tracheal lumen, but may appear much further back if the swelling pushes the esophagus to one side. Sometimes one may encounter an air or gas pocket in the posterior space swelling, due to infection by a gas-producing organism, spontaneous rupture, or a drainage puncture. In some instances we have found the foreign body in the air or gas cavity when it would not have been seen otherwise.

In over 30 cases of abscess diagnosed, about two-thirds were in children, a preponderance accounted for by the anatomical peculiarities of the region as stated and the ease of infection in loose tissues with free lymphatic communications. In adults, the retropharyngeal and retroesophageal tissues are thin, do not have such free lymphatic communications, and are more closely attached. Sharp foreign bodies are more frequently swallowed by adults than by children; hence, the relative frequency of this cause in older life. Foreign bodies are also frequent causes of abscess in children but they are of a different nature, as safety pins, jack stones, and collar buttons. Spinal caries is the least frequent cause of abscess which we have encountered.

**Paralyses:** Attention has been called in a previous communication (4) to the fluoroscopic and roentgenographic appearances in recurrent laryngeal nerve paralysis. This condition is not to be discussed here except in connection with the diagnosis of bulbar
paralysis. In the latter condition there is great difficulty in swallowing. The four most striking abnormalities are lack of contractility of the pharynx, lack of coordinated closure of the air passage, leakage of food into the larynx, and resulting spasm of the glottis with choking. As the food may pass down into the bronchi, great care is necessary in the examination of these cases. There is often associated evidence of vocal cord paralysis. In the presence of this and swallowing difficulties, the diagnosis is largely one of exclusion by the elimination of evidences of disease or tumor in the locality.

We have had occasion to examine one case of myasthenia gravis.

**Fig. 18. Retrolaryngeal and retroesophageal abscess in an adult female, aged forty-six years, following lodgment of a fish bone**

The lumen of the esophagus, faintly outlined by a bismuth streak, seems to be in the center of the posterior swelling, probably because the esophagus is pushed to one side. The air or gas and fluid levels are characteristic of foreign-body abscess, but the appearance must be differentiated from that due to esophageal obstruction and dilatation. This was easily done fluoroscopically.

**Fig. 19. Case illustrated in Fig. 18 after aspiration of some pus through the postpharyngeal wall**

The mottled appearance of the abscess cavity is quite characteristic of the condition.

The patient had considerable difficulty in controlling the tongue, which resulted in poor articulation. Whistling was impossible, as he could not elevate the soft palate to close off the nasopharynx. The soft palate and uvula were more drooping than normal, and the posterior pillars seemed to ride on the base of the tongue. The larynx seemed to occupy an unusually low position. On attempting to swallow, there was practically no upward excursion of the larynx. The general relaxation of the pharynx permitted it and the pyriform sinuses to fill out too readily and completely. There was considerable difficulty in emptying the pyriform sinuses and in keeping food from entering the larynx.
Injuries: The most frequent injuries of the pharynx and upper esophagus are gunshot and stab wounds. We have encountered two retropharyngeal and retroesophageal abscesses resulting from gunshot injuries. In one of these there was extensive osteomyelitis of the cervical vertebrae.

Diverticula: Diverticula involving the regions under discussion are usually of the acquired variety. They are so common, and the literature on the subject is so prolific, that they need no further discussion.

Anomalies: The most frequent anomalies in this region are those involving the epiglottis and esophagus. Anomalies of the epiglottis in infancy are far more common than is generally realized. They have twice been detected in our practice, but their presence has been suspected several times and endoscopy has revealed them. They consist mainly in curling or lateral tilting of the structure, interfering with respiration. It is our belief that these anomalies are frequently the cause of obstructive phenomena ascribed to an enlarged thymus or that they assist that structure in the production of respiratory obstruction. In a number of instances we have found that symptoms of respiratory obstruction and roentgenologic signs of enlarged thymus have not subsided after adequate treatment, and have advised endoscopic examinations. In the cases not showing evidences of recurrent laryngeal nerve paralysis, endoscopy has revealed anomalies of the epiglottis or neighboring structures. Two rather typical cases are worthy of citation:
CASE 1: A female infant, aged five months, was referred for examination to determine the cause of a peculiar inspiratory sound. Tracheal compression by a mediastinal enlargement or enlarged thymus was suspected. Examination showed an enormous dilatation of the stomach by air, causing a marked elevation of the domes of the diaphragm. This shortened the lung fields and pushed the heart and thymus upward to such an extent as to produce an appearance of the trachea simulating the effect of thymic enlargement. The trachea was displaced posteriorly and its lumen was enroached upon. Endoscopy was advised because it was believed that the thymus was not primarily at fault. Direct examination by Dr. Tucker showed a peculiar anomaly of the epiglottis. It was very small, and on inspiration was pulled into the glottis, closing the latter off. This evidently caused air to be sucked into the esophagus and stomach. The child died of pneumonia. Autopsy showed that the small, curled epiglottis was almost fused with the arytenoids, with an exceedingly short aryepiglottic fold.

CASE 2: A female infant, aged four months, was referred for examination because of stridulous breathing and attacks of cyanosis. The thymus was suspected as a possible cause. Fluoroscopic observations of the chest revealed phenomena suggestive of high respiratory obstruction. There were no roentgenographic evidences of thymic enlargement in either sagittal or lateral views. During both phases of respiration, the epiglottis and arytenoids seemed to be in too close relation. Endoscopy was advised. On direct examination, Dr. Tucker found that the epiglottis was curled upon itself and extended toward the left side of the pharynx. The right arytenoid showed impairment of motion. During inspiration the epiglottis seemed to be pulled into the upper laryngeal aperture.

Anomalies of the esophagus are of frequent occurrence. Simpson (13) quotes Cautley's classification of the various congenital anomalies of this structure as follows: complete absence of the esophagus, usually found in monsters; double esophagus, with reunion at the lower end (rare); congenital diverticula, high up and really pharyngeal; cysts; tracheo-esophageal fistulae without other abnormality (rare); congenital dilatation, usually low (rare); atresias without tracheal fistulae; atresias with the lower end opening into the trachea or a bronchus, the usual type.

As the atresias are the only anomalies with which we have had any experience, they are the only ones which will be discussed. Beatty (16), in 1928, referred to 50 recorded cases and reported two additional ones. Vogt (15), in 1929, in a report of six cases, gives a concise classification for roentgenologists, with the expected roentgenological findings, as follows:

1. Complete absence of the esophagus (rare)
2. Upper and lower segments, each ending in a blind pouch
3. Cases with fistulae communicating with the trachea or bronchi
   a. The fistula between the upper segment and the trachea
   b. The fistula between the lower segment and the trachea or bronchi
   c. Fistulae between both segments and the air passages.
The atresia may be complete or a very tight stenosis may be present. In types 1, 2 and 3a, there will be no gas or air in the stomach or intestines. In 3b and 3c, there is usually a large amount of air or gas in both, as air has been admitted into the lower segment through the fistula. Further phenomena are produced by the opaque meal. In type 3a, small amounts of the opaque medium may be observed in the air passages, having traversed the fistula during the attempt to visualize the upper segment, or more may have overflowed into the larynx. In type 3b no opaque medium enters the air passages except by overflow into the larynx. In type 3c there will be air in the stomach and opaque medium in the air passages.

In our first case, examined many years ago, and with slides as our only records, the opaque medium was introduced into an upper pouch by way of a tube through the nose. There was air in the stomach, but no bismuth entered the air passages. It is inferred that this case was of type 3b. The infant was eight days old when examined, and died a day or two later, as is always the case.

A second patient was seven days old when referred by Dr. Tucker, after the diagnosis of atresia had been made elsewhere.
by roentgenogram. Demonstration of air in the stomach and intestines proved that a fistula was present. Dr. Tucker introduced a bronchoscope into the trachea and found a small fistula communicating with the esophagus above the carina level. Through this a small ureteral catheter was introduced into the lower segment of the esophagus and then into the stomach, in the hope that it would reach the duodenum. On introducing bismuth suspension by way of a catheter through the nose to fill the upper segment, there was an overflow through the larynx into the air passages (Fig. 21). The next day a gastrostomy was performed and a tube was passed into the stomach and down into the duodenum. The child died of pneumonia. Autopsy showed that the lower end of the upper segment, the upper end of the lower segment, and the fistula connecting the lower segment with the trachea were all only a few millimeters apart, just above the carina. This case would correspond to type 3b of Vogt. The lower segment was shown to have a normal muscular coat.

Summary

The pharynx, including the oropharynx, is often neglected by roentgenologists because of their belief that little is to be learned by roentgenologic studies. As a matter of fact, it is a very prolific field for such investigations. One must, however, be familiar with the normal appearances at all ages, with the normal mobility and motility of the various structures, and with the physiology of speech and the swallowing act.

The study of the upper food passages includes the oropharynx, pharynx, pyriform sinuses, upper portion of the esophagus, and the adjacent interrelated structures and boundaries.

This presentation deals with normal appearances, inflammatory conditions, neoplasms, paralyses, injuries, and anomalies. Foreign bodies are omitted. The lower esophagus is not considered.

The diagnosis of pathological conditions depends upon changes in the walls which may encroach upon a normally air-filled cavity, upon interference with normal movements of all the structures in the neighborhood, and upon changes in their relations. The upper esophagus must be outlined by an opaque medium, because it is a potential space and is closed under ordinary conditions of rest.

The technic of fluoroscopy and roentgenography is fully described. Fluoroscopy is necessary especially for studying the movements of the various structures during respiration, phonation, and swallowing, and to detect abnormalities in the mobility of the structures concerned.
The sequence of events in the physiology of the normal swallowing act as we have determined them is described in detail.

The fluoroscopic and roentgenographic evidences of tumors, inflammatory conditions, paralyses, and anomalies are discussed.

BIBLIOGRAPHY